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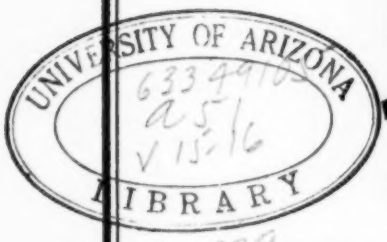

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American Potato Journal

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PROGRESS IN ADVERTISING

Several interesting programs have been started this past year to advertise the potato. It is too early to predict the outcome of these but the message concerning the value of the potato in the human diet has been carried to hundreds of thousands of readers. The program conducted by the state of Maine and made possible by a voluntary tax on sacks imposed at the request of the Maine growers, is reported to be making real progress. Distinctive packages have been developed and shippers who combine the State trade marks with their own brands as well as all manufacturers or suppliers of packaging materials on which the official trade mark is used must be licensed by the Maine Department of Agriculture. In addition, an intensive advertising campaign is being conducted through the newspapers, magazines and the trade press as well as through the domestic science experts in schools and colleges. A radio network program is also being conducted to advertise the merits of the potato.

The National Potato Publicity Board was organized in May, 1937 for the purpose of promoting the more extensive use of white potatoes, and particularly to combat the mistaken notions that have been developed in recent years concerning the role of the potato in the diet. Potato growers and others interested in the industry were asked to support this campaign. While the response was disappointing, excellent progress has been made. The Secretary of the organization, H. B. Tabb, recently reported that four general publicity releases have been made and these were printed in newspapers having a total circulation of more than twenty-three million. These releases were also featured in several national magazines. A real start has been made despite a pitifully small budget. Sufficient has been accomplished, however, to demonstrate that the program is worth while. Those interested in the industry should see that enough money is made available to ensure the continuance of this program.

PRESIDENTIAL ADDRESS

FRED H. BATEMAN

York, Pa.

We are assembled again at the annual meeting of the Potato Association of America—the twenty-fourth since its organization in 1913, and I believe you will agree with me that the work of the Association has been most valuable to the potato industry. Reviewing the objects and purposes for which our Association was organized, we find them just as applicable today as they were twenty-four years ago. All praise to those who drafted them!

What progress have we made? Measured year by year, sometimes it is hard to perceive, but when we look back to the methods and practices that prevailed at the time of the organization of our Association, and compare these with the practices of today, no one can fail to see that great progress has been made. On the other hand, we realize more than ever that only a beginning has been made toward the accomplishment of some of our purposes. How often as we have made one advance step in our experimental work, new fields of endeavor have opened up, challenging us to go further. And so will it be in the years to come—a never ceasing endeavor through study and experimentation—to bring about a greater perfection in methods of culture, a more efficient control of plant diseases, the development of new and better varieties, and not the least—reduced cost of production, and greater profit to the grower.

In a year of over-production and surplus similar to the present, I am reminded that there is one purpose of the Association that I fear has been somewhat neglected. I refer to the one which reads: "To stimulate the investigation of methods for the profitable utilization of surplus and cull potatoes." Because the need for action is only occasional, this important matter is lost sight of until another surplus year is upon us, and the potato grower is confronted with the problem of disposing of his surplus to advantage. We know of course that some territories are able to dispose of surplus and cull potatoes to the starch factories, but all sections are not so favored. I might here call

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Delivered at the 24th annual meeting of the Potato Association of America, in session at the Washington Hotel, Indianapolis, Indiana, Dec. 28 to Dec. 30, 1937.

your attention to the fact that in England, surplus and cull potatoes are used extensively in making silage to feed to hogs. Whether this might be done more extensively in this country, is perhaps a matter for investigation and study. Another possible solution of the surplus problem is, of course, the intervention of the government in securing legislation on Crop Control. Until the present time, little has been accomplished either by the government or the potato interests, to relieve the difficult situation that arises in years of over-production and low prices.

One of the achievements of the year, I believe, has been an appreciable reduction in the cost of potato production, brought about largely by the use of improved machinery, which the grower, because of funds from last year's prosperity, was able to purchase. I refer particularly to the multiple-row-planter, two, three and four rows, planting the seed in rows of uniform width, making possible the use of such important complementary machinery as the General Purpose Tractor, with its cultivating equipment, larger sprayers, and two-row diggers. Although the use of such machinery has been growing steadily since its introduction, it was not until the present year that its use became more general throughout the country, in some sections practically supplanting the use of single-row machinery. Another factor which has contributed to the reduced cost of production is the use of rubber-tires applied to potato machinery. When applied to the planter, in addition to reducing draft, uniform depth and accurate planting are secured, spacing is made more uniform, and the life of the machine prolonged. The provision for using the same tires on sprayers, diggers, transplanters and other machinery, distributes the cost of this equipment, and will encourage its more extensive and general use.

Still another decrease in the cost of production has been brought about by the band-placement of fertilizer, which has produced a very significant increase in yield above that of any other placement method. You are all probably familiar with the work of the National Joint Committee on Fertilizer Application, which has conducted extensive experimental studies with potatoes since 1931, in five different states. Even though the band method of fertilizer placement is of greatest importance to our Eastern growers who are obliged to use large quantities of fertilizer, it will increase in value to our Western growers, as it becomes necessary for them to use fertilizers in increasing quantities.

Other factors which have contributed materially in reducing the cost of production, have been the use of better seed, better fertilizer, better spraying or dusting, better harvesting, grading, storing and marketing, and also the more extensive use of irrigation.

During the past year it has been my privilege to visit many of the potato growing districts of the country, particularly in the Middle and Far Western states, and I was impressed more than ever with the fact that potatoes are grown successfully under so great a variety of conditions, such as soil, climate, and methods of culture, all of which emphasize the fact that there can be no standard method of growing potatoes under the varied conditions that exist in this great country of ours. I was still further impressed by the splendid enthusiasm, resourcefulness, and interest displayed by those in charge of research and experimental work in their respective states, and found every one possessed of the same helpful and co-operative spirit which has characterized my association with workers in all parts of the country. I found in some parts of the West, that the profitable use of fertilizer is still a debatable subject, as no significant results had been obtained where some trials had been made, although in some other parts only a small application had given splendid increased yields. In fact, in talking with a large grower who had increased his yield very materially by having made a small application of fertilizer on a test plot, he humorously remarked that he ought to bring suit against the state for not having insisted that he apply fertilizer to his whole crop.

I wish to speak with commendation of the publicity campaign that has been conducted during the past year by the National Potato Publicity Board, in bringing to the attention of the public, by means of the newspaper and the radio, the many advantages of the potato as an item of diet—its cheapness, its important food value, and the diversity of the ways in which it may be used. Attention has also been given to combating the erroneous idea that white potatoes are more fattening than any of the other foods the housewife may serve.

I also desire to commend the work being done at present by the state of Maine, regarding its education and publicity work, in making known to the public a fund of valuable information regarding the potato and its uses, all of which has a value greater than mere advertising. The state of Idaho has also popularized its potato, and its splendid marketing methods have made the Idaho potato known throughout the country. Such popularization is valuable to all potato growing areas, and will help to increase the consumption. It should be encouraged and endorsed by every one interested in bringing the

potato back to its former and rightful place, as the cheapest, and one of the most beneficial foods available.

Our worthy Secretary deserves the highest praise for the splendid work he is doing and has done in bringing out each month a publication of such high class as our Potato Journal. Although a journal of more popular character would appeal to some of our growers, the purpose of the Journal would be defeated should such a course be followed. The scientific articles found within its pages are the means of disseminating the results of scientific research, and are of the greatest value for reference and for the use of all engaged in investigational work. Much also may be gleaned from its pages by the observant and intelligent growers who wish to keep abreast of, and profit by, the results of investigation.

Not the least of the benefits derived from membership in our Association are the personal contact, and friendships formed among those who are engaged in the common interest of making the potato industry all that it should be, both from the scientific and economic standpoints. I am sure that all who attend these meetings will return to their work greatly benefited from the contacts made, and from the addresses and papers he has heard. I believe the Potato Association has a great future before it, and the inspiration received here will be helpful to all of us, and we will go back to our work with a new enthusiasm.

AVAILABILITY STUDIES ON MAGNESIUM IN MAGNESIC LIMESTONES, SERPENTINE, OLIVINE, AND MAGNESIUM AMMONIUM PHOSPHATE

G. F. LEA AND J. B. SMITH

Rhode Island State College, Kingston, R. Is.

The occurrence of a magnesium deficiency in a number of soils in recent years has stimulated interest in the availability of magnesium in various carriers. The special interests in the availability of the magnesium in magnesic limestones at the present time is caused largely by the fact that this material is being added rather generally to fertilizers to make them less acid-forming. In keeping with this

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trend an experiment at the Rhode Island station was designed to study the availability of magnesium in magnesic limestones collected from various deposits in the Atlantic Coast Region. Prior to the beginning of this experiment the availability of magnesium in several other materials had been tested. These materials included Olivine, Serpentine, and magnesium ammonium phosphate. The results obtained with these materials will also be presented in this paper.

This work has been conducted entirely in the greenhouse. Wagner pots holding 15.5 pounds of soil were used for the tests.

The soil for these experiments was taken from a plat (64 SE) on the experiment station fields where a magnesium deficiency was first noted in 1929. A history of plat 64 and a summary of the results obtained with magnesium sulfate have been reported by Knoblauch and Odland (4, 5).

The plant nutrients in the limestone trials were supplied in the form of a 5-8-4 fertilizer, applied at the rate of 2000 pounds to the acre. The nitrogen, phosphoric acid, and potash were supplied in the respective forms of nitrate of soda, di-ammonium phosphate, and sulfate of potash. The limestones were all ground to 80-100 mesh material and were applied at the rate of 60 pounds of MgO to the acre. Extra nitrogen in the form of nitrate of soda was applied when the foliage required more of this nutrient to maintain a dark green color. For the previous trials the plant nutrients were supplied in the form of a 4-8-2 fertilizer applied at the rate of 3000 pounds to the acre. Nitrate of soda and sulfate of ammonia applied on an equal nitrogen basis supplied the nitrogen. Phosphoric acid and potash were supplied in 16 per cent superphosphate and in muriate of potash, respectively. The limestone, Serpentine, and Olivine were applied on a similar MgO basis which was 405 pounds to the acre. These carriers were also ground to 80-100 mesh material. The magnesium sulfate and magnesium ammonium phosphate were applied at the rate of 64 pounds of MgO to the acre.

Irish Cobbler potatoes were used in the experiment. The seed pieces were cut to a 30-gram size each having one eye. The growing period extended from February to June of each year.

A soil moisture content of twenty per cent was maintained by daily additions of water throughout the experiment. When the crop was mature and the vines dead, the tubers were harvested and the number, size, and weights of both large and small tubers were recorded.

EXPERIMENTAL RESULTS

Potatoes were used in this work because they have proven very sensitive to magnesium and not too sensitive to an acid soil. Corn and buckwheat under similar treatment have not shown nearly so marked a response. The corn has been found not to respond to magnesium in this soil unless lime is also added.

The 1935 experimental results in the greenhouse show the effects of the addition of magnesium sulfate, calcium carbonate, magnesic limestone, magnesium ammonium phosphate, Olivine, Serpentine, and extra potash. The rate of application of these supplements and the resulting tuber yields are presented in table 1.

TABLE 1.—*Effects of various magnesium supplements on tuber yields in pots.* (1935)

	Calculated Pounds Supplement Per Acre	Calculated Lbs. MgO Per Acre	Average Tuber Yields in Gms. Per Pot
None	—	—	113
Calcium carbonate	2000	—	132
Magnesium sulfate	400	64	143
Mag. ammonium phosphate	366	64	155
Mag. sul. and cal. carbonate	400 + 2000	64	176
Magnesic limestone	2000	405	152
Serpentine	1540	405	147
Olivine	1364	405	137
Extra potash	160	—	103
Extra potash and mag. sulfate	160 + 400	64	162

The greater efficiency of magnesium sulfate as compared with this particular magnesic limestone has been very noticeable in pot work for several years. From these results, and other work by Knoblauch (3), it would appear that the magnesium in this limestone is not all readily available to the plant. The magnesium in the Serpentine used is apparently as readily available as it is in the limestone. In the Olivine the magnesium seems to be in a somewhat less available form than it is in the other two carriers.

The data in table 1 also show that extra potash tends to accentuate magnesium deficiency. In both pot and field experiments this has been found to be consistently true. In certain years the efficiency

of magnesium sulfate has been impaired by a high potash level in the soil whereas in other years a similar potash level apparently has shown little effect. Brown (1) reports that the MgO content of Marquis wheat grown in sand cultures was dependent upon the level of potash. As the increments of potash were increased and the increments of nitrogen decreased the magnesium contents of the plants decreased. To avoid any undue influence of potash on magnesium, potash was supplied in comparatively small amounts in the limestone tests.

The results of the greenhouse trials with magnesic limestones of different analysis for MgO but applied to supply equal weights of MgO are presented in table 2. All limestones were applied on a similar MgO basis which was 60 pounds to the acre.

TABLE 2.—*Availability of magnesium in magnesic limestones as indicated by tuber yields*

Sample No.	Per Cent MgO	Tuber Yields in Gms.	Per Cent Increase over Check
Check	—	133.5	—
Limestone 1	12.83	181.5	35.9
" 2	22.42	186.5	39.3
" 3	19.70	167.0	25.1
" 4	22.17	194.0	45.3
" 5	19.30	165.5	24.0
" 6	17.50	145.5	9.0
" 7	22.00	155.5	16.4
Kieserite	24.85	180.0	34.8
Sul. pot.-mag.	10.19	204.3	53.0

These data show an increase of 9 to 45 per cent in tuber yields from the addition of limestones. Only four-fifths of the amount of magnesium applied in the limestone was applied in the form of Kieserite, due to the fact that after the experiment was well under way it was discovered that this material had taken up considerable moisture in storage. This treatment is therefore not strictly comparable with the limestones, although even at the reduced rate it produced higher yields than four of the seven limestones. Sulfate of potash-magnesia yielded the highest percentage of increase. This carried, however, more potash than was added in the fertilizer in the other treatments, and it is quite probable that the increase has been partially due to the extra potash. As has been previously mentioned, a low potash level was chosen, because it was thought that potash would interfere with magnesium and a true index of the availability would

not be obtained. The limestone treatments are comparable and show that there is a considerable difference in the availability of magnesium in magnesic limestones. Greater differences might have been obtained if a higher potash level had been used.

DISCUSSION OF RESULTS

Although the results of this investigation show differences in the availability of magnesium in magnesic limestones, the work should be considered in a preliminary stage, for a number of factors such as optimum levels of potash, calcium, and magnesium have not been fully investigated. The differences in the response of potatoes to various limestones are probably caused by certain characteristics which affect the rate of their disintegration. McIntyre *et al* (6) state that factors which influence the rate of disintegration of a dolomite are its purity, porosity, fineness, type of soil, depth of incorporation, climatic factors, and the generation of acid through bacterial action. The magnesium in a limestone that readily disintegrates in the soil may be free to react with the soil substances and in doing so may become unavailable or less available to the plant for a period. The small amount of magnesium applied in the form of limestone in this experiment may represent only a portion of the total amount that would be necessary to satisfy the requirements of the soil substances, in which case, very little would be readily available to the plant. Data which have not been published, to date, seem to indicate that magnesium in a limestone that readily disintegrates may be fixed in a form which is unavailable to potatoes. The Virginia Truck Experiment Station (2) reports that magnesium in a readily available form may be readily fixed in an unavailable form.

High ratios of calcium to magnesium in the limestone did not appear to be a factor affecting the availability of the latter nutrient. The sample having the lowest per cent of magnesium produced higher yields than the majority of limestones containing a higher per cent of magnesium.

It is possible that Serpentine and Olivine from different deposits vary in composition, and if availability tests were conducted on these materials, it is probable that differences in the availability of magnesium would be found. It, therefore, should not be concluded from this experiment that all Serpentine and Olivine would produce results similar to those obtained.

Summary

The availability of magnesium in different magnesic limestones, Serpentine, Olivine and ammonium magnesium phosphate was studied in pot cultures using Irish Cobbler potatoes grown in a magnesium-deficient soil as the plant indicator. In a similar manner the effect on tuber yields of the addition of calcium carbonate, magnesium sulfate, and extra potash to this soil has been determined. The results may be summarized as follows:

Potatoes were shown to be very responsive to applications of magnesium in the forms of magnesium sulfate and other carriers.

High levels of potash accentuate magnesium deficiency.

Tuber yields indicate a variation in the availability of MgO in the limestones used.

The magnesium in this particular Serpentine and Olivine is in a form available to potato plants, to approximately the same extent as in the poorer magnesic limestones.

Magnesium ammonium phosphate supplied magnesium in a very readily available form.

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EFFECTS OF BORDEAUX MIXTURE AND PYRETHRUM DUST ON LEAFHOPPER CONTROL AND YIELDS OF POTATOES

E. O. Mader and F. M. Blodgett

Cornell University, Ithaca, N. Y.

At the time it was reported [Mader and Blodgett, (*2*)] that 75 to 80 pounds of copper sulfate in the form of bordeaux mixture to the acre during the season gave maximum yields of potatoes, some evidence was at hand to indicate that the increase in yield, in large part was independent of leafhopper control. In order to obtain further information on this point experiments were conducted in which increases due to the effect of copper on the plants could be separated from increases due to insect control. In one case pyrethrum dust was applied for leafhopper control to a section across the various bordeaux sprayed plots and checks. In this way it was hoped to obtain a comparison of the action of different amounts of copper applied as bordeaux mixture in the presence of few insects as compared with the same bordeaux mixtures and checks in areas on both sides where the insects were not controlled independent of the bordeaux mixtures.

Table 1.—*Average number of potato leafhopper nymphs on each plant. (Average of* 10 *plants each)*

Application of Pyrethrum Dust		Date of Counts	Total Pounds of Copper Sulfate Applied on Each Acre During the Season as Bordeaux Mixture						
Date	Pounds to the Acre on Each Application		0	24	36	48	73	96	144
			Without Pyrethrum Dust						
None		8/5	Traces below 1/10 per plant						
		8/20	46.0	17.1	11.4	3.0	1.2	1.1	1.3
		8/30	32.6	14.2	5.3	1.0	.8	1.3	.3
		9/12	29.0	14.8	5.4	1.2	.4	.5	.7
		9/21	8.6	4.6	2.3	.3	.7	.3	.4
			With Pyrethrum Dust						
7/22	100								
8/2	120	8/5	Traces below 1/10 per plant						
8/14	120	8/20	.4	.2	.2	.2	.3	.3	.2
8/28	110	8/30	.2	.2	.2	.3	.2	.2	.2
9/7	50	9/12	.2	.2	.3	.2	.1	.2	.2
——	—-	9/21	.1	.1	.1	.0	.2	.2	.1

TABLE 2.—*Foliage and tuber weights of various treatments harvested at intervals during the season in concentration experiment*

1935

Total of 40 Plants Each in Pounds

Date of Sample	Pounds of Copper Sulphate on Each Acre During Season as Bordeaux Mixture														Differences* Necessary to Give Odds 20:1
	0		24		36		48		73		96		144		
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	
	Foliage Weights														
Aug. 4	20.7	23.2	21.5	26.2	21.7	25.9	22.2	25.9	22.7	26.5	22.0	27.1	23.6	25.5	3.56
Aug. 19	23.8	26.7	24.3	28.1	25.9	30.0	26.1	30.1	27.3	31.0	30.0	33.3	30.7	32.3	3.56
Sept. 2	24.2	26.4	25.4	28.9	25.0	31.5	29.8	31.2	28.8	32.7	29.6	33.9	29.1	34.3	3.56
Sept. 12	19.9	25.8	26.1	28.4	27.2	29.4	26.9	30.3	28.7	29.9	28.7	33.7	29.4	32.7	3.56
Totals	88.6	102.1	97.3	111.6	99.8	116.8	105.0	117.5	107.5	120.1	110.3	128.0	112.8	124.8	7.12
Combined Totals for A & B	190.7		208.9		216.6		222.5		227.6		238.3		237.6		10.07
	Tuber Weights														
Aug. 18	13.9	11.0	11.6	10.2	11.2	9.6	10.2	9.7	9.9	8.5	9.4	8.0	8.8	7.9	5.44
Sept. 2	19.6	23.9	22.5	23.4	21.4	25.4	22.2	26.2	21.4	26.7	20.3	27.1	19.2	25.5	5.44
Sept. 12	21.1	26.7	24.7	27.1	26.0	29.2	28.2	30.5	28.4	32.1	29.7	33.0	27.7	31.8	5.44
Sept. 14	21.5	28.9	34.2	35.2	36.4	39.4	37.4	42.4	42.5	49.8	43.3	50.8	40.3	44.6	5.44
Oct. 2	22.7	29.0	35.4	36.2	37.7	41.1	40.2	44.9	43.9	51.8	45.7	53.4	42.7	46.9	5.44
Totals	98.8	119.5	128.4	132.1	132.7	144.7	138.2	153.7	146.1	168.9	148.4	172.3	138.7	156.7	12.17
Combined Totals for A & B	218.3		260.5		277.4		291.9		315.0		320.7		295.4		17.21

A = Bordeaux spray alone; B = Bordeaux spray plus pyrethrum dust.

* Differences between A & B treatments cannot be judged on this basis because the pyrethrum treatments were confounded with blocks, i. e. all pyrethrum plus bordeaux treatments were in one block and all bordeaux alone was in two blocks at either end of the pyrethrum dust block.

TABLE 3.—*Foliage and tuber weights of various treatments harvested at intervals during the season. Comparing results of foliage and soil treatments with copper sulfate*

Total of 40 Plants Each in Pounds

Date of Sample	Pounds of Copper Sulfate on Each Acre During the Season as Bordeaux Mixture													
	0	24	36	48	72	96	144	0	24	36	48	72	96	144
	No Soil Treatment							Pounds of Copper Sulfate Added to Soil per Acre in Addition to above Bordeaux Mixture						
								144	120	108	96	72	48	0
	Foliage Weights													
July 22	8.1	7.7	7.6	7.4	7.7	7.3	7.3	7.9	7.6	7.4	7.4	7.5	7.8	7.5
Aug. 18	23.8	24.5	26.2	26.1	28.4	30.5	30.2	21.3	22.1	26.4	28.0	28.9	28.3	28.9
	Tuber Weights													
Aug. 18	12.8	11.1	11.4	10.0	9.1	8.4	8.3	11.5	9.8	8.5	7.3	7.0	7.0	7.1
Sept. 12	21.2	24.3	26.1	28.4	29.5	29.9	28.0	17.8	21.4	23.0	26.5	27.1	28.9	28.4
Oct. 2	22.0	34.8	36.7	41.4	43.1	48.4	41.7	19.4	30.0	35.5	37.6	40.8	43.1	43.6

In another case a similarly situated section received soil treatments of pulverized copper sulfate in addition to that used in the foliage treatments, the amounts used being given in table 3.

From the summary of the counts of potato leafhopper nymphs on each plant given in table 1, it may be noted that in the blocks receiving bordeaux mixture only, the number of nymphs decreased as the amount of copper sulfate applied increased. The number of leafhopper adults decreased in the same proportion as did the nymphs. The control of leafhopper nymphs with pyrethrum dust was about equal in the plots receiving different amounts of copper and those not sprayed with bordeaux mixture. Differences occurring in the growth of vines and yields of potatoes among the plots dusted with pyrethrum, therefore, could not be attributed to leafhopper control.

There was an additive control of leafhopper nymphs in the plots where pyrethrum dust was applied in addition to bordeaux mixture. Bordeaux mixture carrying forty-eight pounds of copper sulfate to the acre each season, however, resulted in a 95 per cent control of this

pest. Therefore the additional insects killed by the heavy applications of pyrethrum dust were very few, especially in the plots where sufficient copper sulfate was applied to give maximum yields of potatoes.

When an analysis of variance is made of the foliage weight data, (table 4) it is clear that the bordeaux mixture made a significant dif-

TABLE 4.—*Analysis of variance of foliage weights*

	Degrees of Freedom	Sum of Squares	Mean Square	Snedecor's F Value
Total	223	252.7884		
Blocks	3	1.7405		
Pyrethrum and Blocks	1	44.2864	44.2864	105.29
Bordeaux Concentrations	6	53.1634	8.8606	21.07**
Dates	3	63.4659	21.1553	50.30**
Interactions				
Bordeaux & Pyrethrum	6	.9649	.1608	
Pyrethrum and Dates	3	.1825	.0608	
Bordeaux and Dates	6	9.6741	1.6124	3.83**
Bordeaux, Dates and Pyrethrum	18	4.8662	.2703	
Error	177	74.4445	.4206	

Analysis of Variance of Tuber Weights

	Degrees of Freedom	Sum of Squares	Mean Square	Snedecor's F Value
Total	279	2,919.1834	10.4630	
Blocks	3	2.0223	.6741	
Pyrethrum and Blocks	1	48.5555	48.5555	50.93
Dates	4	2,217.9002	554.4751	581.58**
Amounts Bordeaux	6	185.0374	30.8396	32.35**
Interactions				
Bordeaux & Pyrethrum	6	7.4815	1.2469	1.31
Dates and Pyrethrum	4	26.2834	6.5709	6.89**
Dates and Amounts Bordeaux	24	211.6583	8.8191	9.25**
Error	231	220.2448	.9534	

** Corresponds to odds greater than 99:1.

ference. As the amount of copper applied to the vines was increased the average foliage weight increased. The differences were larger (as might be expected) toward the end of the season than at the beginning.

Also, the increases in foliage weight (table 2), with increasing amounts of copper, occurred similarly in the plots to which pyrethrum dust was applied to control the insects, that is, there were no indications of an interaction in the analysis of variance, table 4, between the

effects of bordeaux mixture and those of pyrethrum dust on foliage weight. In view of the leafhopper nymph counts (see table 1) discussed above, this seems to be strong evidence that neither of these materials was dependent on insect control for their main influence in increasing foliage weights since otherwise bordeaux mixture would have caused greater increases in foliage weight in the absence of pyrethrum and pyrethrum would have caused the greatest increase where bordeaux mixture was not applied.

Since the pyrethrum dust was applied in a solid block across all the replications of plots receiving bordeaux mixture, and compared with similar plots on both sides, the effect of this treatment cannot be separated from that of the block in which all the different combinations with pyrethrum occurred. Therefore no satisfactory basis is available for estimating the standard error of differences between pyrethrum combinations and bordeaux mixture alone. In spite of this, the rather consistent gains in foliage weight, obtained by applications of pyrethrum dust in addition to bordeaux mixture that run through all of the different amounts of copper sulfate applied from 0 to 144 pounds to the acre as well as in all of the replications across the field, certainly are a strong indication that there was a real effect of the pyrethrum dust in increasing foliage weight. This apparent increase in foliage weight in the pyrethrum-dusted plots was as marked early in the season as later. This is shown in the analysis of variance, which gave no indication of "interaction" between dates of sampling and application of pyrethrum. Accordingly the first indication of increased foliage weight was at a date so early that it can scarcely be attributed to leafhopper control.

The tuber weights obtained corresponded with the foliage weights already discussed with certain exceptions which might have been anticipated from previous work. As in the case of the foliage weights, the tuber weights increased both as to totals for all the dates of digging and weights at the last digging as the amount of copper sulfate applied was increased from 0 to 96 pounds to the acre during the season. However, there was a significant interaction in the analysis of variance of yields, table 4, between dates of digging and amounts of copper applied, that is, at the earliest date of sampling there were *most* potatoes where the least copper was applied, although this situation was soon reversed as the season advanced.

Also the application of pyrethrum dust caused an apparent increase in tuber weight both in the total for all the dates and for the final digging, but, as explained in the discussion of foliage weights,

no way was found to test the significance of this. The pyrethrum dust applications were all made in one block for comparison with bordeaux mixture alone on both sides; using Fisher's terminology (1) the application of pyrethrum is confounded with blocks in the analysis of variance. In this case likewise there was a signficant "interaction" in the analysis of variance of yields, table 4, between dates of sampling and applications of pyrethrum dust, the pyrethrum dusted with larger vines gave a lower yield early in the season but went ahead at the later dates.

In tuber yield as well as in foliage weight there was no interaction in the analysis of variance, table 4, between the amounts of bordeaux mixture applied and whether or not pyrethrum dust was applied in addition. In this way the rather numerous leafhoppers early in the season on plots receiving no bordeaux mixture, or 24 pounds of copper sulfate in the form of bordeaux mixture without pyrethrum, seem to have produced very little effect on the results. It appears that pyrethrum, aside from its insecticidal value, exerts a stimulating effect on the growth of potato plants. This assumption is supported by the fact that in recent experiments pyrethrum dust was found to practically double the numbers of blossom clusters [Mader and Udey (3).]

When copper sulfate was applied to the soil (table 3) in addition to foliage treatment, a reduction in yields occurred in all instances,—the larger the portion of copper applied to the soil, the greater the reduction. There was also a parallel reduction in foliage weights. Under the conditions of this experiment, at least, applications of copper to the foliage were beneficial whereas applications to the soil were not.

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RECENT DEVELOPMENTS IN POTATO BREEDING: REVIEW OF LITERATURE

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This paper, a report of the Research Committee on Potato Breeding, is intended to serve as a survey of the results which have been accomplished in the various phases of potato breeding, both in the United States and in foreign countries, as shown by papers published during the year 1937. A few papers, believed to be of special interest, which appeared late in the preceding year after the publication of the last report, are also included. Much of the material from foreign sources has been derived from the abstracts published by the Imperial Bureau of Plant Genetics, Cambridge, England.

The general trend of potato breeding investigations seems to be toward disease resistance, with cytological studies occupying a prominent position, particularly with respect to wild species and species hybrids. Much has been accomplished in the field of the genetics of the potato by the comprehensive studies of a few investigators.

MISCELLANEOUS

A paper by Stevenson and Clark (27) outlines the methods of potato breeding, records the results accomplished by the U. S. Department of Agriculture and cooperating institutions and gives lists of known potato species with their chromosome numbers, also lists of material known to have characters of breeding value.

Perlova (14) gives an account of tests of commercial varieties, wild species and hybrids in three sections of different altitudes in Pamir, (U. S. S. R.). The reaction of many of these to environmental conditions is noted.

Among the interspecific crosses obtained by Bukasov (2) hybrids of *Solanum rybinii* have shown much promise with respect to early maturity. Hybrids and back-crosses of *S. andigenum* have been found to be high in starch content and in yield. A combination of frost resistance and late blight resistance has been obtained by using *S. demissum* as a parent.

In breeding for early maturity Veselovsky (29) found that exceptionally early forms could be obtained by crossing certain early

varieties of *Solanum tuberosum* but that in most cases the yields of the hybrids were low. By back-crossing these hybrids more productive varieties were produced. Crosses between varieties of *S. tuberosum* and *S. andigenum* generally gave late-maturing progeny though some exceptions were found.

Classification

Perlova (15) has described and tabulated the dimensions of the seeds of fourteen cultivated and twenty-one wild species. In general, the seeds of the cultivated forms were larger than those of the wild, with no depression on the periphery. In the wild species the depression is mostly sharply defined and only rarely entirely absent.

A system of classification of cultivated and wild species and varieties based on differences in the structure of the seed coat has been developed by Orechova (13) for laboratory identification.

Inheritance

Great variation was found in the flower color of the material studied by Emme (6) which consisted of crosses between species of the Tuberosa group, with the exception of *Solanum commeae* which belongs to the Pinnatisecta group. The genetic factors concerned with the production of the various colors are postulated as follows: An^{sp}, the gene for the presence of anthocyanin on the upper surface of the corolla; An^{inf}, the corresponding gene for anthocyanin-pigmentation on the under surface; Cr and Cy, gene respectively reducing and raising the pH in the cells of the corolla, resulting in the production of shades ranging from reddish purple to raspberry red in the first case and in the second case producing a blue-purple or blue shade; a further factor, Fl, is tentatively postulated for the presence of yellow pigments in the cell sap. The loci of Cr and Cy are considered to be the sites of a series of allelomorphs conditioning the infinite variety of intensity of the colors due to these two genes. In general, blue appears to be dominant to red and both blue and red dominant to white.

Lunden (11) concludes that the results obtained by himself and by other investigators show that the duplicate factors found in the potato do not segregate independently but in accordance with the modified segregation ratios determined by autotetraploid inheritance. This holds especially for the color factor P and for the immunity

factor X. The results for D did not show such a close agreement, which was considered due to a different degree of double reduction.

The following factors were found to be concerned in the inheritance of color of tubers, sprouts, stems, flowers and inflorescence:

R = factor for red tuber color (type 2, color in cortex); also color in stem internodes, petioles and inflorescence. Rd plants have pale red or nearly white tubers.

E = factor for red tuber color (type 1, color chiefly in periderm); also color in stems, especially in wings and wings of leaflets, the callus, the young roots at the base of the sprout, and the flowers. Ed plants have very pale red tubers and white flowers.

D = a complementary factor to both R and E.

D + R gives red tubers (type 2) and increases the effect of R in stem, leaf and inflorescence.

D + E gives red tubers (type 1) and increases the coloration of stems, wings and callus, also gives red-purple flowers.

D in absence of R and E gives some anthocyanin color in the stem and inflorescence as well as red-purple sprouts with colored tips.

D = also complementary to F, the factor for flower color.

F = factor for flower color. Flowers red-purple in presence of D (and G).

P = factor for blue-purple color (anthocyanin). Changes both red tuber-color and red-purple flower-color to blue-purple.

P + R and P + E, respectively, in absence of D, give pale blue-purple tubers of both color types.

P + F, in absence of D, gives pale-blue to blue flowers.

G = complementary factor for flower color besides D and F.

S = factor for distribution of color on surface of tubers.

W = a dominant factor that gives normal chlorophyll formation in the simplex condition (Wwww); wwww plants are albinos.

V = another dominant factor that gives normal chlorophyll in the simplex condition; vvvv plants are yellow-green.

X = a dominant factor causing immunity to Synchytrium in the simplex condition and independent of any other immunity factor.

Y and Z = complementary factors that give immunity when both are present, even in the simplex condition. They are independent of X.

No linkage has been observed between the immunity factors and the color factors, E, R, D, P or F.

Cytology

Sepeleva (*22*) discusses the morphology of the chromosomes of six wild species and a cultivated variety of *Solanum tuberosum* and gives illustrations of the different chromosome shapes in each.

A study of forty British varieties by Ellison (5) showed the presence of giant pollen mother cells in only one variety, Arran Crest. Some of the giant cells had several nuclei, eleven being observed in one. Others possessed only one nucleus, which was large, with numerous chromosomes.

Beilis (1) has described abnormalities which he found in meiosis and the later stages of microsporogenesis. The irregularity of meiosis in the pollen mother cells arising from chromosome unbalance is considered to be the cause of sterility in the potato. Normal development was found to prevail in the embryo sacs except in the case of two varieties, Lotus and Wohltmann-Zaikevitch.

In cytological studies of species with 24, 36, 48 and 72 somatic numbers, respectively, Propach (16) found that the higher the degree of polyploidy the more frequent were the groups of high valency. He suggests that secondary association should only be taken as significant evidence for homolgy when primary associations of similar valency also occur. He concludes that the basic number of the section *Tuberarium* is to be taken as 12.

Schwarz (21) discusses the results of cytological studies of a triploid form obtained by crossing an F_1 hybrid ($2n = 24$) of *Solanum phureja* ($2n = 24$) X *S. rybinii* ($2n = 24$) with *S. acaule* ($2n = 48$).

Disease Resistance

In a recent paper Stelzner (*26*) reviews the work of various investigators in breeding for resistance to the principal potato diseases. Material is cited which has proved to be of value for this purpose.

Studies have been made by Emme (7) of the immunity of triploid hybrids derived from crosses between *Solanum rybinii* ($N = 12$) and two varieties of *S. antipoviczii*, viz., var. *grandarae* and var. *reddickii*, also *S. ajuscoense* var. *candelarianum*, each of which has the haploid chromosome number of 24. The F_1 hybrids, which had the somatic chromosome number of 36, were sterile. Indications of autosyndesis with the formation of 18 units at first metaphase also of an apparently more or less regular disjunction of the 18 partners,

lead this investigator to suggest that the basic number in *Tuberarium* may be 6 and not 12. There was almost complete dominance of the principal morphological characters of the 48 chromosome parents, e.g., growth habit, leaf type, flower color and structure of the floral parts.

All the triploids obtained were resistant to *Phytophthora* and to viruses.

Sidorov (23) reports the results of tests for resistance to late blight in wild and cultivated species. Nine wild species were found to be immune, viz., *Solanum demissum, S. semidemissum, S. verrucosum, S. antipoviczii, S. ajuscoense, S. vallis-mexici, S. polyadenium, S. coyoacanum* and *S. bulbocastanum*. Of the cultivated species *S. andigenum* is considered to contain the greatest number of forms resistant to *Phytophthora*. Good breeding results were obtained by back-crossing on a large scale *S. tuberosum* on hybrids between *S. demissum* and *S. tuberosum*.

In another paper Sidorov (24) gives an account of the work at the Krasnyi Pakhar Institute in breeding for resistance to *Phytophthora*. Of the cultivated species of South America the Colombian and Bolivian forms of *Solanum andigenum* appear to offer the greatest possibilities for breeding for resistance to this organism. *S. demissum* and *S. antipoviczii* are considered to be the most promising of the wild species for this purpose. The geographical center of forms immune to *Phytophthora* is held to be Mexico where nine immune forms have been found.

In extensive tests of European, Indian and South American cultivated varieties, as well as wild species, Mundkur *et al* (12) found a large proportion to be susceptible to late blight. One European variety, President, was fairly resistant. Five Indian varieties showed a slight degree of resistance. Of the one hundred twenty-four South American varieties of *Solanum tuberosum* tested, six were highly resistant. Of the wild species studied *S. demissum, S. neoantipoviczii, S. neoantipoviczii*, var. *reddickii* and *S. antipoviczii* were immune.

Lehmann (10) has determined the reaction of certain wild *Solanum* species to the 8 physiological forms of *Phytophthora infestans* now known. The following 3 groups of species have been distinguished: Species susceptible to all physiological forms; all strains of *S. acaule, S. chacoense, S. fendleri* and nearly all *S. verrucosum* strains; species resistant to some forms and susceptible to others; remaining *S. verrucosum* strains, all *S. antipoviczii* strains, *S. demis-*

sum Lindley strains and *S. demissum utile;* species resistant to all forms; *S. ajuscoense, S. demissum el desierto* and *S. demissum tlaxpehualcoense.*

Studies to determine the resistance to late blight in commercial varieties and their hybrids have been made by Stevenson *et al* (28). Resistant seedlings of good commercial type have been obtained from a cross between two resistant varieties, S. 45349 X Ekishirazu; from a cross between a resistant and a susceptible variety, No Blight x Katahdin; and one seedling from a cross between two susceptible varieties, Chippewa x Katahdin. The tubers of a number of these showed a high degree of resistance to the tuber rot caused by *Phytophthora infestans.* The results have demonstrated that it is possible to produce varieties which possess a fairly high degree of resistance to late blight combined with high yield and good quality.

Reddick (17) points out some of the difficulties that are to be encountered in breeding for resistance to late blight, particularly in crossing the cultivated potato with the resistant wild species *Solanum demissum.* Studies of the response of the material in the 1936 tests to the hot, dry conditions which prevailed during that season showed that considerable drought tolerance was exhibited by several of the varieties and seedling progenies.

Anatomical studies of eight species and varieties by Kargapolova (9) failed to show any definite relation between certain morphological characters (leaf structure, stem structure, pigmentation of skin of tubers, number of eyes, number of lenticels, thickness of periderm) and resistance to *Phytophthora.*

In the tests conducted by Jones and Vincent (8) with seedlings developed from crossing and selfing eleven varieties and their seedling progenies, it was found that only one variety, Katahdin, transmitted to its progeny resistance to the veinbanding virus.

Schultz *et al* (20) report the results of extensive tests of the reaction of varieties and seedling progenies to various viroses. Katahdin was very highly resistant to mild mosaic under field conditions but contracted the disease in graft tests. Tests of progenies of Katahdin selfed and of No Blight x Katahdin showed that resistance to this disease is inherited as a dominant character which is heterozygous. Inoculation by field exposure, leaf rubbing and grafts failed to produce latent mosaic in Seedling 41956. Katahdin was also resistant to this disease in field exposure tests but became infected by tuber-grafts.

Tests of resistance to the blackleg organism (*Bacterium phy-*

tophthorum Appel) have been made by Stapp (25). Of the twenty-five varieties tested under field conditions only one, Sickingen, proved to be highly resistant. No definite relation was found between resistance and time of maturity, thickness of skin, capacity for wound cork formation, starch content or rate of decomposition of the parenchyma of the tuber.

Resistance to common scab (*Actinomyces scabies* (Thax.) Güssow) in progenies consisting of crossed and inbred lines has been studied by Darling (3). Although no immune forms were obtained, resistant seedlings were found in progenies resulting from both methods of breeding. The progenies of certain inbred resistant seedlings were nearly all resistant, the progeny of certain susceptible seedlings all susceptible, whereas other susceptible seedlings produced both susceptible and resistant progeny. Scab resistance was considered to be dependent to a large degree on lenticel structure. The lenticels of susceptible seedlings were found to be much larger and the complementary cells rounder and more loosely arranged than in the resistant forms.

Schlumberger (19) reports that of the varieties tested for the third consecutive year in 1936 for resistance to scab only *Volltreffer, Weisses Rössl* and *Frühauf* satisfied the requirements for practical resistance, that is, at least 60 per cent of marketable tubers.

Frost Resistance

Rzavitin (18) describes tests of frost resistance in cultivated and wild species, varieties and hybrids. Two methods were used: (1) freezing the plants in pots in a cold greenhouse or refrigerator, and (2) the determination of the electrical conductivity of the aqueous extract obtained from plants injured by frost. In tests by the first method *Solanum demissum* and *S. ajanhuiri* showed a little injury at 24.8° F. and none at 25.7°. *S. semi-demissum* and *S. goniocalyx* X *S. bukasovii* showed considerable damage and *S. curtilobum, S. andigenum* f. *taccla* and *S. tuberosum Switez* severe injury at 25.7°. *S. pureja, S. andigenum* f. *caiceda* and some varieties of *S. tuberosum* were completely killed at this temperature. The results obtained by electrical conductivity corresponding with those obtained by the first method. In a specially constructed freezing chamber *S. acaule* was only slightly damaged at 17.6°. Certain forms of *S. demissum* showed no injury at 23.0°.

Dremliug (4) records the steps that were followed in producing triple hybrids in connection with the work of breeding for frost re-

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sistance of the Polar Station, Khibini, (U.S.S.R.). These hybrids withstood a temperature of 22.1° F. Examinations of root-tip cells showed the somatic chromosome numbers of the different hybrids to be 72, 74 and 139-142. It is suggested that the occurrence of these numbers may be due to the effect of low temperature in promoting the formation of unreduced gametes since the crosses from which these hybrids were obtained were produced under low temperature conditions in the fall.

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REVIEW OF RECENT LITERATURE

Effect of soil reaction on growth, yield, and market quality of potatoes. ORA SMITH. (*Cornell Univ. Agr. Exp. Sta. Bul.* 664. (1937), pp. 1-21).

Smooth Rural potatoes were grown on thirty permanently located plots of varying degrees of acidity and alkalinity during the five years of 1932 to 1936 inclusive. The original reaction of the soil was pH 5.4 to 5.7. The hydrogen-ion concentration of certain plots was increased by the addition of sulfuric acid in 1932 and decreased by the addition of hydrated lime to some of the plots in each of the first four years. Soil reaction was the only factor that was purposely varied. A range in soil reaction of approximately pH 4.75 to 8.00 was maintained after the first year.

The vine growth is less vigorous and the foliage a lighter green on soil that is too acid when compared with plants on soil where the reaction is favorable. Early death of the plants, however, is another indication of a too-acid soil.

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Similarly, vine growth is less vigorous and the foliage is a lighter green on soil that is too alkaline than where the reaction is favorable. Early death of the plants also occurs, although not so early as on the highly acid soils.

The rate of emergence was slower in the most alkaline plots, whereas in the most acid plots germination was slow during the first and second years but most rapid during the third year after an application of the sulfuric acid.

Final stand of plants and the number of stems on each plant were not influenced by soil reaction within the range studied in these experiments.

Soil reactions more acid than pH 4.8 resulted in a reduction in the number of tubers to each plant.

At the higher soil pH values there is a marked reduction in the number of No. 1 size and in the total number of tubers to each plant.

Plants on the most alkaline soils produce smaller No. 1 size tubers as well as a lower percentage of No. 1 size than do those on less alkaline or on acid soils.

Potato yields were reduced on soils more acid than about pH 4.8.

In general, no significant differences in total yield exist among plots with reactions of approximately pH 4.8 to 7.1. Significant decreases in yields occur in plots with a soil reaction higher than about pH 7.0 to 7.5.

With the scabby tubers removed, the highest percentage of U. S. No. 1 grade potatoes on the most acid and the most alkaline soils and the lowest percentage from soils with a reaction between pH 6.0 and 7.0, sometimes as high as pH 7.8.

There was a gradual increase in the percentage of scabby tubers from the most acid plots to those with the following reactions: pH 6.51 to 6.58 in 1932; pH 7.8 to 7.95 in 1933; pH 6.94 to 7.53 in 1934; pH 7.34 to 7.37 in 1935, and pH 6.71 to 6.76 in 1936. In soils above these reactions the percentage of scabby tubers is always markedly reduced.—(Author).

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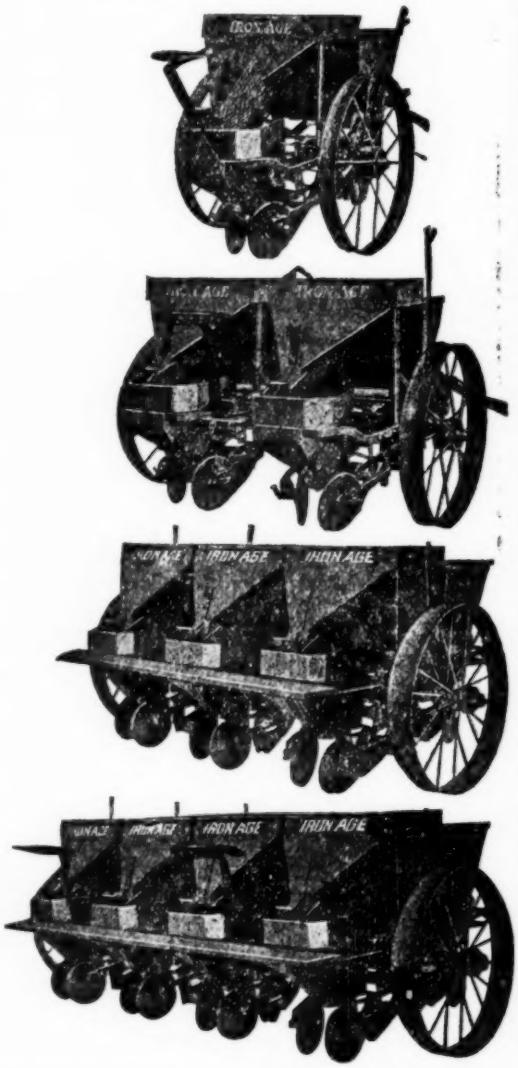

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